Let $$\log n = \log [\log B - \log b - 0{\cdot}00004 \,.\, (M - m)] + 1{\cdot}8261420 + \log (836 + A + a)$$
$$= \log [\log B - \log b - 0{\cdot}00007 \,.\, (M' - m')] + 2{\cdot}0814145 + \log (500 + A' + a')$$
$$= \log [\log B - \log b - 0{\cdot}00009 \,.\, (M'' - m'')] + 2{\cdot}1783245 + \log (400 + A'' + a''),$$

then $$h - H = n + {\cdot}001 \,.\, nl + h'' - H'',$$

where $$1{\cdot}8261420 + \log 900 = 2{\cdot}0814145 + \log 500 = 2{\cdot}1783245 + \log 400 = 4{\cdot}7803845 = \log 60309{\cdot}19.$$

This form requires less previous preparation, avoids the logarithms of numbers near to unity as $\left(1 + \frac{A + a - 64}{900}\right)$, and allows of the use of foreign data to obtain the result in English feet, so that it only becomes necessary to reduce the height of the lower station to English measures.

V. "Bessel's Hypsometric Tables, as corrected by Plantamour, reduced to English Measures and recalculated." By Alexander J. Ellis, Esq. Communicated by Dr. Neil Arnott. Received February 23, 1863.

These Tables, with the preliminary explanations respecting their correction and reduction, have been, by direction of the Council, communicated to Admiral FitzRoy for insertion in the "Meteorological Papers published by Authority of the Board of Trade," and will appear in the twelfth Number of the series.

April 16, 1863.

Dr. WILLIAM ALLEN MILLER, Treasurer and Vice-President, in the Chair.

Pursuant to notice given at the last Meeting, the Right Honourable Sir Edmund Walker Head, Baronet, was proposed for election and immediate ballot.

The ballot having been taken, Sir Edmund W. Head was declared duly elected a Fellow of the Society.

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The following communications were read :—

1. "On Ozone." By E. J. Lowe, Esq., F.R.A.S., F.L.S. Communicated by Sir J. F. W. Herschel, Bart. Received March 16, 1863.

(Abstract.)

This paper consists of two parts, viz. :—

1. On the precautions necessary in ozone observations, and on certain corrections requisite before the actual amount can be determined.

2. The discovery of dry ozone powders as a substitute for the ordinary tests; an investigation into the ozone paper tests of M. Schönbein and Dr. Moffat, the determination of a proper formula for the tests, with an account of various observations and experiments made on the subject.

Part I.

At the last Meeting of the British Association I read a paper on the precautions and corrections requisite in order that a more perfect knowledge of ozone might be obtained. These precautions comprise uniformity of observation, each observer using the same box and the same tests, suspended at the same height, and as nearly as possible placed under the same circumstances. The corrections necessary are:—1st, For the velocity of the air; 2nd, for the height of the barometer; 3rd, for temperature; 4th, for the hygrometrical state of the air; 5th, for elevation above the ground.

1. *Velocity of the Air.*—The greater the speed the more ozone will be apparent, and this seems to be owing more to the increased velocity of the air than to a greater proportion of ozone.

2. *Height of the Barometer.*—It is found that during the last four years,

With the barometer at $28\frac{1}{2}$ inches the amount of ozone was 5·7

,,	,,	29	,,	,,	,,	3·5
,,	,,	$29\frac{1}{2}$	,,	,,	,,	2·0
,,	,,	30	,,	,,	,,	1·3
,,	,,	$30\frac{1}{2}$	,,	,,	,,	0·4

A law as regards ozone and pressure is clearly apparent; but as the barometer falls for wind, the excess at low pressures is no doubt partly due to the increased velocity of the air. There is more ozone with the wind between W.S.W. and S.S.E. than when between

N.N.W. and E.N.E., and the barometer is half an inch lower with S.W. winds than with N.E. winds.

3. *Temperature.*—Temperatures between 30° and 40° will give less ozone than when between 40° and 50°, and the latter less than when between 50° and 60°. The same holds good when the ozone box is artificially warmed. This does not extend to very high temperatures, because the great dryness of hot weather is against the action of ozone on the tests.

4. *Moisture.*—Increase of moisture up to a certain point is favourable to the colouring of the tests, beyond which it operates unfavourably; for when the air is completely saturated with moisture, the effect of ozone is at its minimum.

5. *Altitude.*—The higher the test is hung the darker will be the colour obtained. The difference is as 4 to 6 between 4 feet and 35 feet above the ground.

There are yet several other circumstances to be mentioned:—

1. *Hour of the Day.*—The difference between the ozone readings at night and in the daytime are—

In June and July an excess at night of		0·1
In August and September	,,	0·4
In October and November	,,	0·5
In December and January	,,	0·8
In February and March	,,	0·7
In April and May	,,	0·7

the average excess of the summer months being only one-half of that which occurs in winter,

2. *Direction of the Wind.*—There is most ozone with the wind between S. and S.W., and least when between N. and N.E.

3. *Protection of the test from light.*—It is absolutely requisite that the test should be in a dark box; and no box has been found to answer so well as that constructed by myself, and known as "Lowe's Ozone box," an account of which has been furnished to the Royal Society* and to the British Association. This box, if freely exposed, and made to veer with the wind, so as always to present the opening to the direct current, is everything that could be desired.

The foregoing observations will be sufficient to show that precautions are requisite in these records, and that certain corrections are

* Proceedings, vol. x. p. 531.

necessary before we can declare whether ozone is present in a certain fixed amount, or whether it changes from hour to hour. These corrections have yet to be found out; those for the height of the barometer and the force and direction of the wind will be considerable.

Part II.

The ozone tests heretofore used have appeared to me to be unsatisfactory, and, on close examination, I found them to be faulty in many respects. The paper used had a glaze upon it, which prevented the solution from penetrating it; substances, moreover, had been used in its manufacture which acted injuriously on the tests. Again, the starch of commerce was found to be impure; it is manufactured with lime, sulphuric acid, and chlorine, substances fatal to these tests. The iodide of potassium was also impure; and there has been a want of uniformity in the proportions of starch and iodide of potassium employed by different observers.

Having found out that the starch of commerce was impure, I procured a jar of wheat-starch in the wet state before any chemicals had been used. This was steeped in distilled water, which was changed every two days until quite sweet to the taste, and, although by a long process, a chemically pure starch was thus obtained.

Sir John Herschel suggested trying other vegetable starches; I therefore made starch from rice, potato, sago, and wheat.

I obtained chemically pure iodide of potassium from Mr. Squire of Oxford Street, who forwarded me two samples made expressly for these experiments, the one prepared with water, the other crystallized several times from alcohol.

On the recommendation of Dr. R. D. Thomson, 15 grains of prepared chalk have been added to each ounce of air-dried starch to prevent it from becoming sour from any moisture that might be contained in it; subsequent observations have proved that this is absolutely requisite for uniformity of effect, as the intensity of action depends upon the amount of water contained in the starch, which is apparent from the following experiment:—

Tests made with air-dried starch—

α. Without further drying became coloured in 5 minutes.

β. After further drying by fire-heat for 1 minute became coloured in 7 minutes.

γ. After further drying by fire-heat for 3 minutes became coloured in 9 minutes.

δ. After further drying by fire-heat for 10 minutes became coloured in 13 minutes.

ϵ. After further drying by fire-heat for 30 minutes became coloured in 20 minutes.

η. With chalk added became coloured in 20 minutes.

With regard to the calico or paper used for the tests, both stained when impure. However, Mr. Joseph Sidebotham of the Strine Works prepared for me some chemically pure calico, and I was also enabled to procure a very porous chemically pure paper, both of which answer perfectly.

Having succeeded with the ozone slip tests, I tried as a first experiment a mixture of 10 parts of starch to 1 of iodide of potassium as a "dry-powder test;" this, when well mixed in a mortar, was bottled ready for use. A small portion was placed in the open air, and ten minutes' exposure showed that powder tests were an undoubted success, being more sensitive than the test slips. My next determination was what strength would colour quickest, and accordingly a number of strengths were prepared, varying in the proportions from 1 of iodide of potassium and 1 of starch up to 1 of iodide of potassium and 30 of starch, the starch used being made from wheat. From these experiments it was found that the proportion of 1 of iodide of potassium to 5 of starch was invariably the darkest, the degree of darkness diminishing in either direction when other strengths were used; thus 1 of iodide of potassium to $4\frac{1}{2}$ of starch, or 1 to $5\frac{1}{2}$, were neither so dark as with a strength of 1 to 5.

On repeating these experiments with potato-starch, the proportion that coloured soonest was 1 to $2\frac{1}{2}$; and this second series of experiments proved that with each starch a special formula is requisite.

My next experiments were with the view of ascertaining the effect of various acids and chemical substances on the ozone powder tests. For this purpose I procured a number of cups for solutions, and small pill-boxes to hold the powder tests, and these were placed together under separate bell-glasses. The result was that the following coloured the powder tests very rapidly:—Hydrochloric acid, nitric acid, nitrous acid, chloride of lime, phosphorus, iodine (in scales),

iodine (dissolved in alcohol), carbonate of iron on which sulphuric acid was poured, carbonate of iron on which glacial acetic acid was poured, limestone on which sulphuric acid was poured, limestone on which glacial acetic acid was poured, matches lighted under the bell-glasses. The following did not colour the tests:—Sulphuric acid, glacial acetic acid, carbonate of lime, carbonate of iron, ammonia, matches not lighted.

The substances used in the manufacture of ordinary starch of commerce gave the following: —

Chloride of lime coloured the tests instantaneously.

Sulphuric acid did not colour the tests.

Lime did not colour the tests.

Lime and sulphuric acid mixed coloured the tests rapidly.

There are advantages in the powders over the ordinary tests. They are more sensitive, and therefore more rapidly acted upon; they retain their maximum colour, not afterwards fading, as with the tests of Schönbein and Moffat. (However, my calico and porous-paper tests are not nearly so liable to fade, owing to the solution penetrating into the fabric used, instead of being merely a surface-covering.) There is also a more important advantage still to be mentioned from the use of powders. By the aid of powder tests we shall ascertain what colours the tests; in the experiments it was found that a different colour was imparted to the powder, and that the colour penetrated deeper with some substances and acids than with others, so that differences of effect took place, from which the different materials used might be recognized. Thus:—

1. Iodine, although coloured a brown-black, was merely a surface colouring, below the powder remained colourless.

2. Phosphorus, bluish black on the surface only, below almost colourless.

3. Chloride of lime, deep brown on the surface only, the powder below slightly yellow.

4. Hydrochloric acid, grey-pink on the surface only, the powder beneath orange.

5. Nitric acid, dark-red brown extending slightly into the powder, beneath that colourless.

6. Carbonate of iron with glacial acetic acid, yellowish brown to the thickness of cardboard, below that buff.

7. Limestone with sulphuric acid, pale brown to the thickness of cardboard, beneath slightly coloured.

8. Carbonate of iron with sulphuric acid, black to the depth of a quarter of an inch.

9. Nitrous acid, dark brown more than the eighth of an inch deep, beneath yellowish brown.

10. Nitric acid mixed with exposed ozone powder, blue-black to the sixth of an inch deep, below that reddish brown.

11. Nitric acid mixed with unexposed ozone powder, blue-black to the sixth of an inch deep, below that reddish brown.

These experiments may require some modification, yet they point out the fact that striking differences are apparent, differences which must open up a new method of investigating ozone.

Not only have the tests hitherto used been made without due regard to the pureness of the chemicals and fitness of the material used, but the paper box in which they have been kept is not sufficient for their perfect preservation; a dark, dry, air-tight box is essential; and this should not be opened in a room where there is iodine, chlorine, nitric acid, phosphorus, hydrochloric acid, or other chemicals likely to be injurious to the tests. I am now manufacturing the tests, which will be distributed by Messrs. Negretti and Zambra, and I have constructed a proper box in which in future they will be sent.

II. "On the Equations of Rotation of a Solid Body about a fixed Point." By WILLIAM SPOTTISWOODE, M.A., F.R.S. Received March 21, 1863.

(Abstract.)

In treating the equations of rotation of a solid body about a fixed point, it is usual to employ the principal axes of the body as the moving system of coordinates. Cases, however, occur in which it is advisable to employ other systems; and the object of the present paper is to develope the fundamental formulæ of transformation and integration for any system.

The integrals found are—

$$p_1=\sqrt{\frac{k^2-(S+\theta_2)h}{\theta-\theta_2}}\cos am\left(\sqrt{\frac{\theta_2-\theta_1}{\nabla}}\sqrt{k^2-(S+\theta)h}\,t+f\right);$$

$$q_1=\sqrt{\frac{k^2-(S+\theta_2)h}{\theta_1-\theta_2}}\sin am\left(\sqrt{\frac{\theta_2-\theta_1}{\nabla}}\sqrt{k^2-(S+\theta)h}\,t+f\right);$$